



Innovative Science and Technology Supporting National Security

Laboratory-Directed Research and Development

Developing cutting-edge science and
technology for core missions

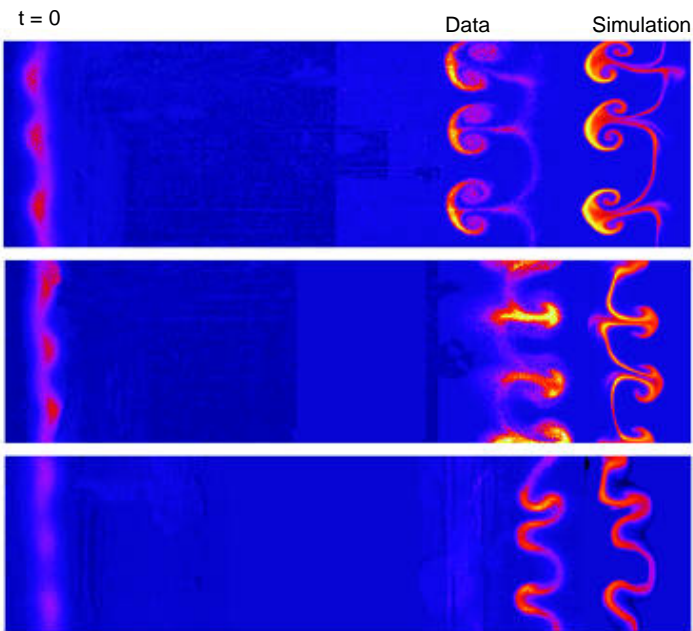
Strengthening the science and technology
foundations to respond to emerging missions

Maintaining scientific vitality by attracting the
best science and engineering talent

Los Alamos
NATIONAL LABORATORY

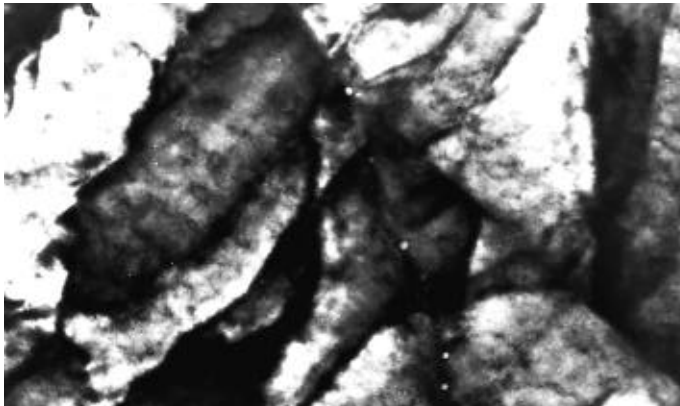
Science-Based Stockpile Stewardship

Without nuclear testing our fundamental understanding of the underlying science of nuclear weapons performance must be greater. We are developing new ways to make the measurements we need.



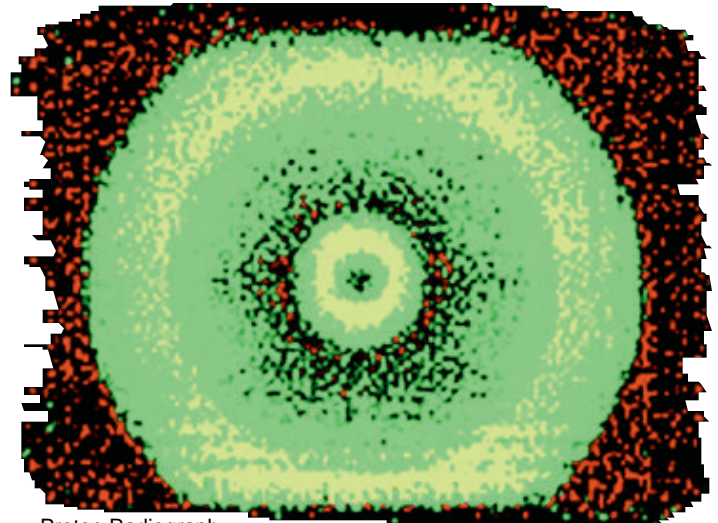
Mach 1.2 shock

◀ Interfacial instability of a thin fluid layer driven by shock compression is a fundamental issue in understanding turbulent mix in nuclear weapons. Scientists are developing a new measurement technique called multiple imaging of laser-sheet illumination (MILSI) to obtain "snapshots" of the evolving instability. The information obtained with MILSI leads to more accurate simulation models and improved computational results.



Helium bubble formation

▲ Researchers are investigating helium bubble formation and distribution in aged plutonium metal using transmission electron microscopy, small-angle neutron scattering, and other advanced techniques such as positron annihilation. They are also developing the tools to evaluate the effect of this and other aging phenomena on properties that are germane to nuclear weapons safety and performance.

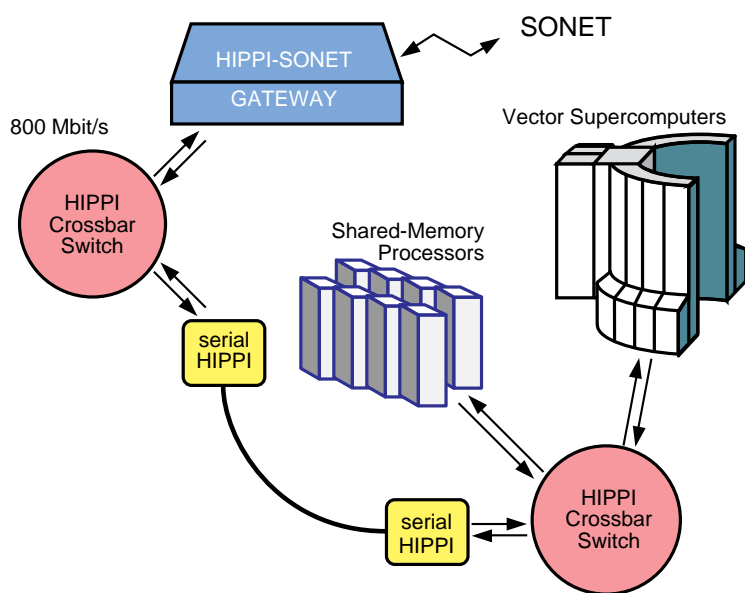


Proton Radiograph

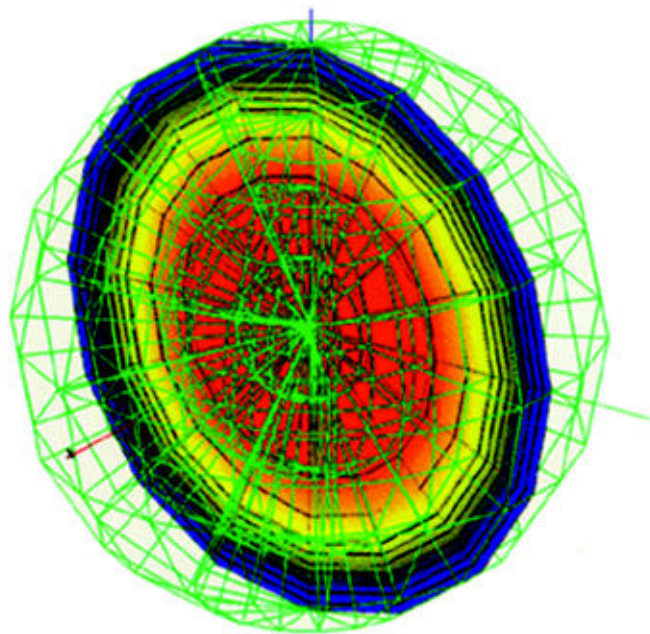
▲ Scientists are exploring the use of high-energy protons to make high-resolution radiographs of very rapid events in high-density materials. Shown is a proof-of-principle proton radiograph of a test object (the most dense areas are in red and least dense in blue). Proton radiography complements neutron and x-ray radiography and has the potential for providing tomographic movies of an implosion of a simulated warhead.

Advanced Computational Capabilities

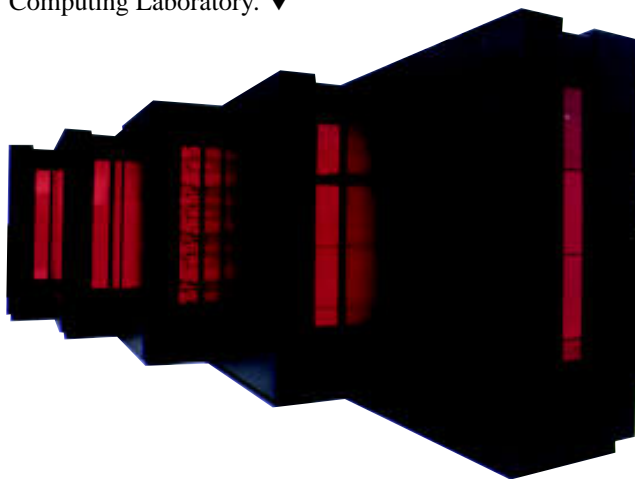
Maintaining a safe, secure, and reliable stockpile for the foreseeable future will increasingly depend on high-fidelity computer simulations of nuclear weapons performance.



◀ Invention of the high-performance parallel interface (HIPPI) has made it possible to transfer computational data, such as that generated in nuclear weapons simulations or global climate modeling, at the rate of 800 million bits per second (equivalent to one-hundred, 250-page books per second). The HIPPI has also enabled the development of a synchronous optical network (SONET) gateway that can link supercomputers at HIPPI speeds over wide-area networks.



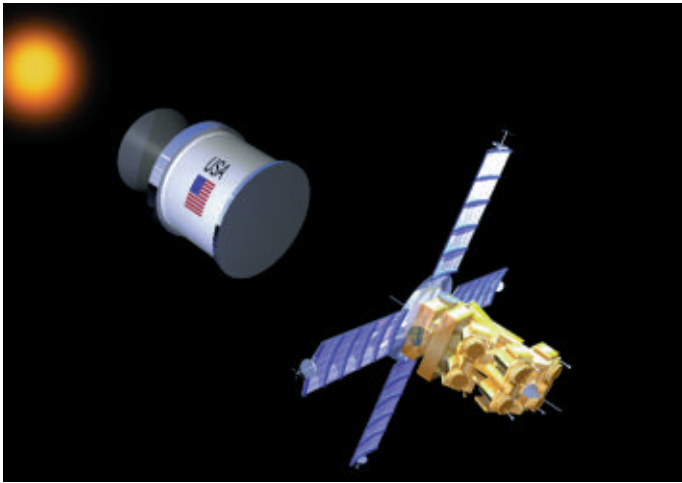
LDRD investigations of computer architectures and applications software to address complex problems have enabled the development of the "connection" generation of massively parallel computers that are now part of the weapons computational base. Shown is the Connection Machine CM-5, which has 1024 nodes (processors) and is located in the Advanced Computing Laboratory. ▼



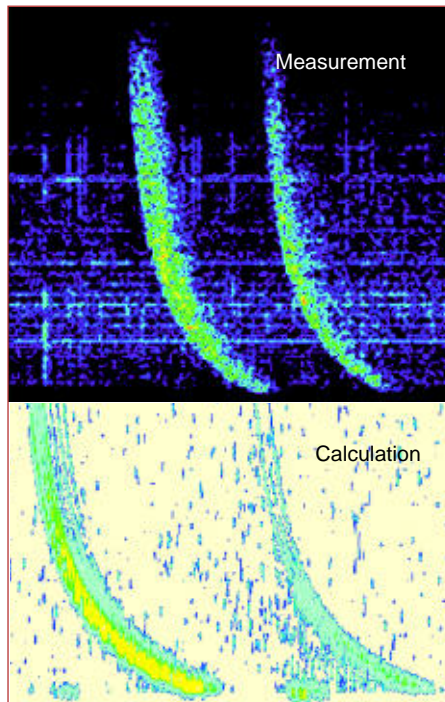
Scientists are developing advanced computational techniques to model radiation and material flows in complex three-dimensional geometries. Shown is the application of a massively parallel algorithm for solving the three-dimensional neutral-particle spherical-harmonics equations on unstructured tetrahedral meshes (in green). The highest particle flux is in red and the lowest in blue. ▲

Nonproliferation and Counterproliferation

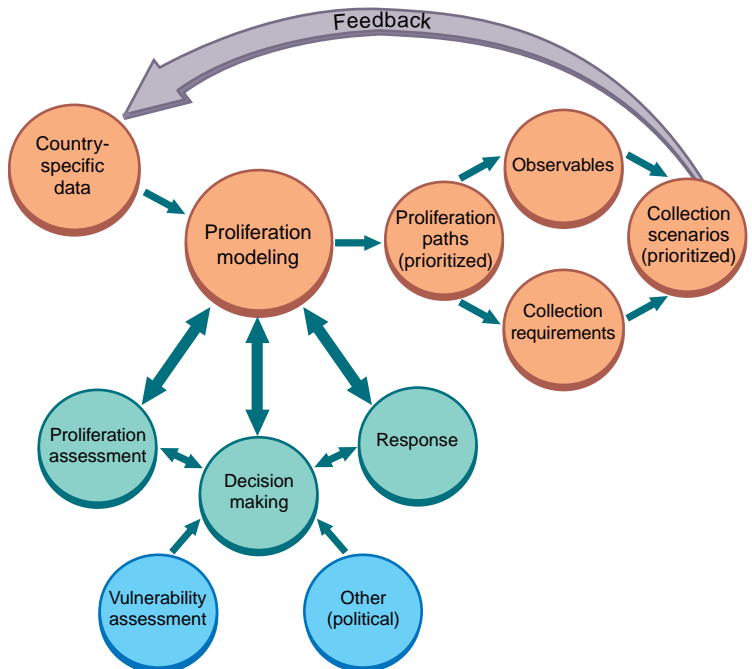
The end of the Cold War and the new world order have increased the risks associated with nuclear proliferation, diversion, and terrorism. We are developing a variety of tools to address these threats.



▲ The science and technology of satellite remote sensing is a rapidly growing interdisciplinary field that has many global and regional applications, including nonproliferation. Investments are being made in sensors, systems, and comprehensive detection modeling. Shown is an artist's conception of a sensor satellite.



Researchers are developing models that, from a global perspective, will provide an understanding of the management, control, and flow of weapons-grade nuclear material. This work is vital to proliferation modeling and assessment and is an aid to developing nonproliferation technology and strategies. ▼



◀ Earth-orbiting satellites have detected transionospheric pulse pairs that are similar to signatures generated by a nuclear explosion. Scientists have now shown that these signals can be explained by a runaway electron mechanism near thunderstorms that causes upward-propagating discharges ("sprites"). The new theory agrees with measurements of radiofrequency "chirp" pairs (shown), as well as with optical and x-ray emissions associated with this phenomenon. This understanding will allow scientists to more accurately identify signals from clandestine nuclear explosions.

Conventional Defense

Maintaining a strong conventional defense capability in the face of decreasing budgets requires a greater reliance on innovation and advanced technologies.



▲ Advanced techniques are being developed to ignite jet turbine engines at lean mixtures and to provide robust reignition at high altitude after flameout. This technology has important applications in both the civilian and defense sectors. (Shown is a military jet used in peacekeeping operations.)

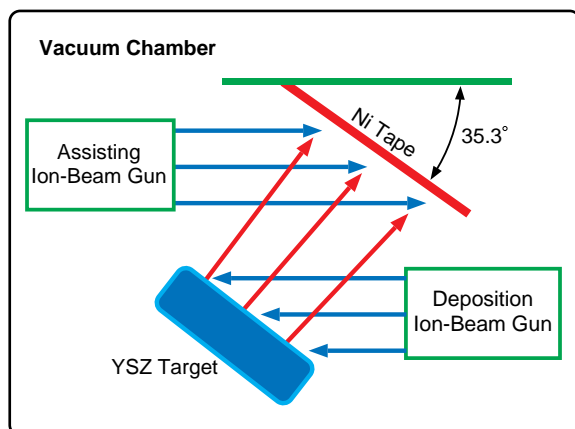
Resonant ultrasound spectroscopy is being used for the nondestructive testing of military components and for identifying the contents of chemical munitions. Shown is a portable field instrument that is used to rapidly and noninvasively examine and identify the contents of sealed containers. ►



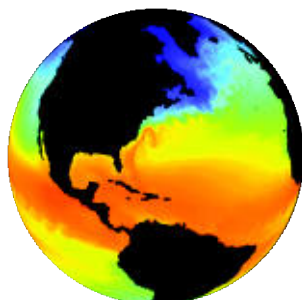
◀ Active light detection and ranging (LIDAR) technology uses lasers to detect chemical agents in the field and for aircraft identification. This technology also has civilian applications such as measuring air quality above metropolitan areas.

Seeds for the Future

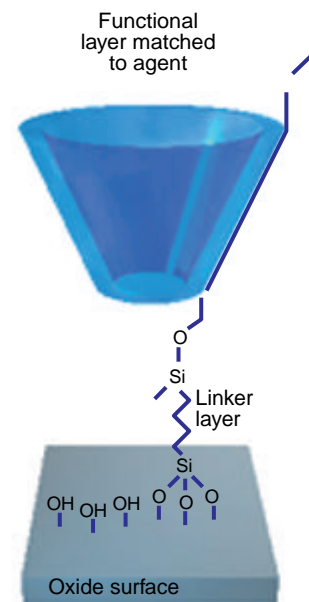
Fundamental research is providing breakthroughs that will enable critical science and technology elements in both our defense and civilian missions.



◀ By understanding how film deposition parameters affect superconductor properties, scientists recently achieved a new world record for current density in a flexible high-temperature superconductor tape. As shown, two separate ion beams are used to deposit and align a buffer layer of zirconia grains on nickel tape. A pulsed laser beam then vaporizes and deposits the superconducting layer on top of the buffer layer to complete the process.



◀ Accurate three-dimensional modeling of the Earth's interior, lithosphere, oceans, and atmosphere (and the coupling among these) is providing new insights into the essential relationships that govern the environment. Results of a global simulation of ocean surface temperatures is shown (red is warmest, blue is coldest).

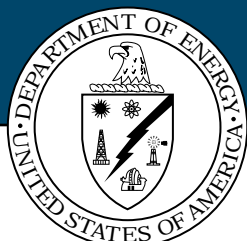


Using molecular self-assembly techniques, researchers have developed compact microsensors for remote, real-time, reversible sensing of volatile organic compounds. Shown is the three-layer (surface, linker, and functional layers) structure of these sensors. The functional (sensing) layer is constructed from cyclodextrin, a molecular "bucket" that reversibly traps organic toxins. ▲

Laboratory-Directed Research and Development (LDRD) is a program conducted at the Department of Energy national laboratories with the authorization of the United States Congress. LDRD provides the laboratory directors the flexibility they need to maintain the scientific and technological vitality of their institutions. This brochure focuses on a few examples of LDRD contributions to the national security missions of the Los Alamos National Laboratory.

For more information,
contact the LDRD Office
at (505) 667-1235

Los Alamos
NATIONAL LABORATORY



Production credits

Writing: Ed Heighway and John Vigil, STB

Editing: Mable Amador, CIC-1

Design: Gloria Sharp, CIC-1

Cover photograph: LeRoy N. Sanchez, PA-3

LALP-96-149